MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY.

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Dr. LEE, President, in the Chair.

Rev. F. Howlett, Hurst Green;
Edmund Wheeler, Esq., 11 William Street, Upper Holloway;
Capt. H. C. Johnstone, 5th Bengal European Regiment;
Rev. M. A. Smelt, Heath Lodge, Petersfield; and
Andrew Yeates, Esq., 12 Brighton Place, New Kent Road,

were balloted for and duly elected Fellows of the Society.

Note on Prof. Wolf's latest Results on Solar Spots.

By Joseph Baxendell, Esq.

In the "Abstract of his latest Results" (*Monthly Notice* for January 1861), Prof. Wolf announces the law that "greater activity on the Sun goes with shorter periods, and less with long periods;" but with reference to this law, it may be remarked, that although the numbers given by Prof. Wolf indicate a higher range of activity in short than in long periods, they also show that the total amount of action from one minimum to another is not materially influenced by the length of the period. Thus five periods, averaging 9·98 years each, give the mean value of the total amount of action = 449·2; whilst four periods, averaging 12·65 years each, give the mean value = 438·0. The near agreement of these two numbers for periods differing so considerably in length shows that the total amount of action cannot be regarded as being dependent to any great extent upon the length of the period; and it appears, therefore, that the higher range of activity in

short periods is, in fact, due to this near approach to equality in the amount of total action in periods of different lengths. There is, however, a remarkable relation indicated by Prof. Wolf's results which, though not noticed by him, is, perhaps, hardly less important and instructive than the law which he has announced.

If we denote by R the ratio of the intervals from minimum to maximum, and from maximum to minimum, we find that

Five periods, having a mean value of 12·36 years, give $R = \frac{5\cdot12}{7\cdot24} = 0\cdot707$

Five periods, mean value 9·98 years ... ... $R = \frac{4\cdot54}{5\cdot44} = 0\cdot834$

Five periods, having a mean maximum activity of 96·12, give ... ... $R = \frac{3\cdot78}{7\cdot10} = 0\cdot532$

Five periods, having a mean maximum activity of 62·44, give ... ... $R = \frac{5\cdot88}{5\cdot58} = 1\cdot053$

Five periods, having a mean total amount of action = 544·38, give ... ... $R = \frac{3\cdot78}{7\cdot10} = 0\cdot532$

Four periods, having a mean total amount of action = 319·12, give ... ... $R = \frac{5\cdot97}{5\cdot55} = 1\cdot075$

The mean value of R from all the periods in Prof. Wolf's list is ... ... $R = \frac{4\cdot83}{6\cdot34} = 0\cdot761$

It appears, therefore, that the value of R is least in long periods and periods of great activity, and greatest in short periods and periods of diminished activity. Variations in the amount or in the maximum intensity of action, have, however, greater influence than changes in the length of the period.

As most of the variable stars have very unequal rates of increase and decrease of brightness, and as the ratio of these rates is also found to be affected by changes in the length of the period and in the range of variation of brightness, Prof. Wolf's results for the Sun give additional importance to the view taken by some astronomers, that the solar spots and the phenomena of the variable stars are produced by similar agencies.

Manchester, Feb. 20, 1861.

On the Persistency during three days of two light Patches on a Solar Spot. By W. R. Birt, Esq.

On the 9th of July, 1860, between $3^h\ 30^m$ and 5^h G.M.T., I observed and figured an interesting solar spot on the southern

hemisphere of the sun, fig. 1. It consisted of a somewhat large nucleus surrounded by a penumbra, the northern part of which was separated from the main body by a bridge of light, and several small spots were seen as outlines, mostly in the direction of the longest diameter of the penumbra.

Fig. 1.

1860, July 9, 4^h 45^m.

The most interesting features characterising this spot were:—

1°. A dark tongue or spur of a curved form, the convexity being towards the nucleus, it was *only just* attached to the main body of the nucleus and *apparently* a portion of it.

2°. Bordering the eastern part of the nucleus, and partially separating the dark tongue or spur, a bright patch of light was seen, A, fig. 1.

3°. Another bright patch of light was noticed north of the spur, and projecting from the curved portion at a considerable angle, B, fig. 1.

On the 11th of July, between 4^h 30^m and 5^h G.M.T., I again figured the same spot, fig. 2; every portion had undergone a very considerable change, the outlines of both nucleus and penumbra having altered materially, the surface of the

Fig. 2.

1860, July 11, 4^h 45^m.

Fig. 3.

1860, July 12, 4^h 15.

penumbra appeared to be exceedingly mottled from numerous small light patches scattered over it, the spur seen on the 9th was recognised as well as the two light patches, A and B, fig. 2, the relative positions being unchanged both as regarded direction and locality in the spot.

About 24 hours later, viz. on July 12th, from 3^h 30^m to 5^h G.M.T., all the features of the spot, except the spur and the two light patches, had undergone very remarkable changes, the nucleus was much elongated, and the spur entirely separated, the penumbra exhibited appearances of having been subject to considerable agitation (see fig. 3) at the western extremity of the nucleus, a lighter portion surrounding it crossed by a narrow and dark bridge appeared to have drawn the material of the penumbra westwardly, while the two light patches seen on

the 9th and 11th maintained their positions (A and B, fig. 3), the outline of the penumbra was very irregular, and towards the eastern extremity was broken into several angles, a portion of the penumbra itself being separated from the main body of the spot by the two persistent light patches.

It is not a little remarkable, and a matter that deserves close attention, that while every other portion of the spot underwent considerable change, the two patches of light with the spur maintained at least the same relative positions with regard to each other; observed at first in the eastern portion of the spot, while evidence was afforded of increasingly energetic action by which the nucleus was elongated *westwards* and the penumbra driven in the same direction, the patches of light preserved nearly the same form and inclination to each other accompanied by the spur (a part of the nucleus), which although it did not alter its relative position with regard to them, yet underwent modifications in form which did not appear to affect them. It would seem that from the neighbourhood of the two light patches a force of sufficient energy to extend the spot westwardly was in active operation, while eastwardly the action was confined to modifying the penumbra and altering the form of the spur.

On the Apparent Rotation of a Solar Spot.

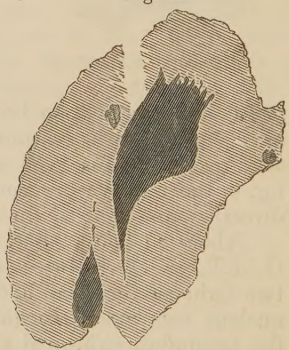
By W. R. Birt, Esq.

On the 29th of October, 1860, about 23^h G.M.T., I carefully observed and figured a solar spot, see sketch, fig. 1. The

Fig. 1.

1860, Oct. 29, $23^h\ 0^m$.

Fig. 2.



1860, Oct. 31, $22^h\ 30^m$

next opportunity I had of viewing this spot was on October 31, about $22^h\ 15^m$, when I again made a sketch of it, see fig. 2.

During the 47 hours and a quarter that elapsed between the two a very considerable change had taken place, and some indications of rotation were afforded.

The spot on the 29th presented a feature by no means rare, viz. the presence of a principal, and also of a secondary nucleus, the breadth by estimation* of the southern or broadest part of the principal nucleus was about 15″, the longest diameter being directed towards the north-west, the nucleus ending in a fine point, the eastern side of the nucleus being convex while the western was concave. The secondary nucleus was westward of the principal, irregular in its form, the northern part being curved, the parallelism of the two nuclei was distinctly apparent.

The outline of the penumbra presented the ordinary irregular character, the curved portion of the secondary nucleus and the outline of the penumbra were in contact.

On the 31st, a remarkable change was observed in the two nuclei, the southern portion of the principal nucleus was still the broadest, and occupied much the same position, but the two sides were altered exceedingly, the western side was smoothly convex; and the eastern smoothly concave with a marked protuberance. As on the former occasion the nucleus terminated towards the north in a fine point.

The secondary nucleus had changed its form and position considerably, it appeared as if all its material had progressed so as to have met with such a resistance as to have produced a smooth curvilinear outline, broadest at the front and gradually tapering to a point, the figure strongly suggests the idea of semi-fluidity, the same contact of the penumbral outline with the front of the secondary nucleus observed on the 29th was also seen on the 31st, but in such a position as strongly to suggest a rotation of the entire spot, and also that the secondary nucleus in its motion northward had turned the point of the principal nucleus, the centre of motion being in the neighbourhood of the broadest portion of the principal nucleus.

The longest diameter of the spot was much in the same direction as on the 29th, it however appeared more marked on the 31st, as the spot was foreshortened by its approach to the limb, the parallelism of the two nuclei being very apparent, but not in the direction of the longest diameter of the spot.

On November 1^{d} 21^{h} 15^{m}, G.M.T., I obtained another sketch, fig. 3, of this spot. As it approached the limb, it not only apparently, but I apprehend really, increased in magnitude, the evidence of rotation being still very marked around the southern part of the principal nucleus. It would appear that this part of the nucleus had become broader, the point observed on the two former occasions was blunted and a

* This estimation was obtained by means of an etched glass micrometer, constructed for me by L. Casella, Esq., the value of each division being a little more than 1′.

somewhat thick dark line extended from the principal towards the secondary nucleus, which had evidently increased considerably in size since Oct. 29th. As on the two former occasions the parallelism of the two nuclei was maintained, the further indication of rotation consisting in the advance of the secondary nucleus in an eastward direction, the whole body of the spot being apparently carried round with it.

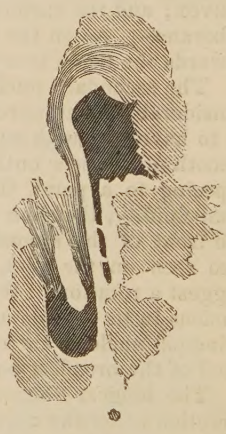
On the 31st of October a streak of light divided the penumbra in the neighbourhood of the south-western part of the principal nucleus, this had so considerably increased by November $1^d\ 21^h\ 15^m$ as to leave a portion of the principal nucleus without any penumbral appendage, the contact of the secondary nucleus with the edge of the penumbra being still maintained.

Nov. $2^d\ 21^h\ 45^m$. Nearly the same features were presented accompanied with an evident arrestation of the rotatory movement, and a very slight divergence from parallelism in the two nuclei. Sketch, fig. 4, exhibits the appearance of the spot at

Fig. 3.

1860, Nov. 1, $21^h\ 30^m$.

Fig. 4.



1860, Nov. 2, $21^h\ 30^m$.

this epoch, and shows the great change that had supervened in the positions and appearances of the nuclei during the 95 hours the spot had been under observation; this sketch is very instructive, and indicates, I apprehend unmistakeably, that the apparent rotation is due to the motion of the secondary nucleus, sketches 2 and 3, exhibiting successive steps in the divergence of the nuclei, a fact spoken of repeatedly by Mr. Carrington. Shortly after the completion of sketch 4 the long thin line nearly connecting the principal with the secondary nucleus was observed breaking up into two or three small

spots; and during the progress of the sketch the penumbra underwent change, several lucid portions within its boundary were noticed near the nuclei, and generally much more energetic action was manifested upon the cessation of the apparent rotatory motion than while it was in progress; there also appeared to be indications of internal curvilinear motion.

An Auxiliary Table for the Easy Calculation of Log. sin. and Log. tan. of Small Arcs. By S. M. Drach, Esq.

The table which I herewith offer to the Royal Astronomical Society has been found by me to be very useful, especially at the beginning of the quadrant, obviating the necessity of interpolations in the ordinary "small arc log. sin., &c." table, and could be appended in detached portions to seven fig. logs. of numbers. Thus to find, by means of it, log. sin. and log. tan. of $7'\ 34''{\cdot}82$.

$$7'\ 34''{\cdot}82 = 454''{\cdot}82$$

Log $454''{\cdot}82$	$= 2{\cdot}6578396$		$2{\cdot}6578396$
Tab. $8'$ sin.	$= 4{\cdot}6855745$	Tab. $8'$ tan.	$4{\cdot}6855756$
log. sin $7'\ 34''{\cdot}82$	$7{\cdot}3434141$	log. tan.	$7{\cdot}3434152$

But for this purpose the logs. of numbers must be extended to 10800.

A great advantage would result from prefixing a column to the No. in the logs. of numbers indicating the deg. and min. of the No., considered as denoting a number of seconds.*

With such a table the proportional logarithms of nautical tables might be dispensed with, the constant for 3^h or 3° being 10800 or $4{\cdot}0334238$. Thus, suppose the Greenwich three hourly distances of the Moon from a star, according to the *Nautical Almanac*, be $1^\circ\ 12'\ 21''$, and the observer finds his corrected distance to be $1^\circ\ 4'\ 12''$, the interval for Greenwich time would be thus computed:—

C. log 10800 (3^h)	$= 4{\cdot}0334238$
Subtract log 4341 ($1^\circ\ 12'\ 21''$)	$3{\cdot}6375898$
	$0{\cdot}3958340$
Add log 3852 ($1^\circ\ 4'\ 12''$)	$3{\cdot}5846863$
$2^h\ 39^m\ 21^s{\cdot}4 = 9561''{\cdot}4 =$ log.	$3{\cdot}9805203$

* This is done at the foot of the page in Bremiker's Tables, Berlin, 1852.—Ed.

The Greenwich interval is then $2^h\ 39^m\ 21^s{\cdot}4$, and the number 3958340 in the *Nautical Almanac* column in lieu of the "P. L. of Diff." (no log. index required), would give nearer results, with the advantage of not changing the formula sine, cosine, &c. to the P. L. cosec., sec., &c.

Auxiliary Table for Small Arcs.

To find the log. sin. or the log. tan. add to the log. number of seconds the number in the column sin. or tan. of this Table. The number to be added commences 4·685, the columns of the Table giving the remaining decimals.

Arc. ° ′	No. of Secds.	sin = 4·685 +	Diff.	tan = 4·685 +	Diff.
0 1	60	5748	...	5748	...
2	120	5748	...	5749	...
3	180	5748	...	5750	...
4	240	5748	...	5751	...
5	300	5747	...	5752	...
6	360	5746	...	5753	...
7	420	5746	...	5755	...
8	480	5745	...	5757	...
9	540	5743	...	5758	...
10	600	5742	...	5760	...
11	660	5741	...	5763	...
12	720	5740	...	5766	...
13	780	5738	...	5769	...
14	840	5737	...	5773	...
15	900	5735	...	5776	...
16	960	5733	..	5780	...
17	1020	5731	...	5784	...
18	1080	5728	...	5788	...
19	1140	5726	...	5792	...
20	1200	5725	...	5898	...
21	1260	5722	...	5803	...
22	1320	5719	...	5808	..
23	1380	5716	...	5813	...
24	1440	5713	...	5819	...
25	1500	5710	...	5825	...
26	1560	5707	...	5831	...
27	1620	5704	...	5838	...
28	1680	5700	...	5845	...
29	1740	5698	...	5852	...
30	1800	5694	...	5859	...
31	1860	5690	...	5867	...
32	1920	5686	...	5874	...
0 33	1980	5682	...	5882	...

Arc. ° ′	No. of Secds.	sin = 4·685 +	Diff.	tan = 4·685 +	Diff.
0 34	2040	5678	...	5890	...
35	2100	5674	...	5899	...
36	2160	5669	...	5907	...
37	2220	5665	...	5916	...
38	2280	5661	...	5926	...
39	2340	5655	...	5935	...
40	2400	5651	...	5945	...
41	2460	5646	...	5955	...
42	2520	5641	...	5965	...
43	2580	5635	...	5975	...
44	2640	5630	...	5986	...
45	2700	5624	...	5996	...
46	2760	5619	...	6008	...
47	2820	5613	...	6019	...
48	2880	5607	...	6031	...
49	2940	5602	...	6043	...
50	3000	5595	...	6056	...
51	3060	5590	...	6068	...
52	3120	5585	...	6080	...
53	3180	5577	...	6093	...
54	3240	5570	...	6106	...
55	3300	5564	...	6120	...
56	3360	5556	...	6133	...
57	3420	5550	...	6147	...
58	3480	5543	...	6161	...
0 59	3540	5535	...	6175	...
1 0	3600	5528	...	6190	...
1	3660	5521	...	6204	...
2	3720	5514	...	6220	...
3	3780	5506	...	6235	...
4	3840	5498	...	6251	...
5	3900	5490	...	6266	...
6	3960	5482	...	6282	...
7	4020	5473	...	6298	...
8	4080	5465	...	6315	...
9	4140	5457	...	6332	...
10	4200	5448	...	6349	...
11	4260	5440	...	6366	...
12	4320	5432	...	6384	...
13	4380	5422	...	6402	...
14	4440	5413	...	6419	...
15	4500	5404	...	6438	...
1 16	4560	5395	10	6457	18

Arc. ° ′	No. of Secds.	sin = 4·685 +	Diff.	tan = 4·685 +	Diff.
1 17	4620	5385		6475	
18	4680	5376	9	6494	19
19	4740	5367	9	6514	20
20	4800	5357	10	6533	19
21	4860	5347	10	6552	19
22	4920	5337	10	6572	20
23	4980	5327	10	6593	21
24	5040	5317	10	6614	21
25	5100	5306	11	6634	20
26	5160	5296	10	6655	21
27	5220	5286	10	6676	21
28	5280	5275	11	6698	22
29	5340	5263	12	6719	23
30	5400	5252	11	6741	22
31	5460	5242	10	6764	23
32	5520	5230	12	6785	21
33	5580	5219	11	6808	23
34	5690	5208	11	6331	23
35	5700	5195	13	6854	23
36	5760	5184	11	6878	24
37	5820	5172	12	6901	23
38	5880	5161	11	6926	25
39	5940	5149	12	6950	24
40	6000	5136	13	6973	23
41	6060	5124	12	6999	26
42	6120	5112	12	7024	25
43	6180	5099	13	7048	24
44	6240	5086	13	7074	26
45	6300	5074	12	7100	26
46	6360	5061	13	7125	25
47	6420	5048	13	7152	27
48	6480	5034	14	7178	26
49	6540	5021	13	7205	27
50	6600	5008	13	7232	27
51	6660	4994	14	7259	27
52	6720	4980	14	7285	26
53	6780	4967	13	7313	28
54	6840	4953	14	7341	28
1 55	6900	4939	14	7369	28
			14		29

Arc. ° ′	No. of Secds.	sin = 4·685 +	Diff.	tan = 4·685 +	Diff.
1 56	6960	4925	15	7398	28
57	7020	4910	15	7426	28
58	7080	4895	14	7454	30
1 59	7140	4881	14	7484	29
2 0	7200	4867	15	7513	30
1	7260	4852	15	7543	29
2	7320	4837	15	7572	30
3	7380	4822	15	7602	31
4	7440	4807	16	7633	30
5	7500	4791	15	7663	31
6	7560	4776	16	7694	31
7	7620	4760	15	7725	31
8	7680	4745	16	7756	31
9	7740	4729	15	7787	33
10	7800	4714	16	7820	32
11	7860	4698	17	7852	32
12	7920	4681	16	7884	32
13	7980	4665	16	7916	33
14	8040	4649	16	7949	33
15	8100	4633	18	7982	33
16	8160	4615	16	8015	34
17	8220	4599	16	8049	34
18	8280	4583	18	8083	33
19	8340	4565	17	8116	34
20	8400	4548	17	8150	35
21	8460	4531	17	8185	35
22	8520	4514	18	8220	34
23	8580	4496	17	8254	36
24	8640	4479	19	8290	35
25	8700	4460	17	8325	36
26	8760	4443	18	8361	36
27	8820	4425	18	8397	36
28	8880	4407	18	8433	37
29	8940	4389	18	8470	36
30	9000	4371	19	8506	37
31	9060	4352	18	8543	37
32	9120	4334	19	8580	37
33	9180	4315	19	8617	38
2 34	9240	4296	18	8655	38

Arc.	No. of Secds.	sin = 4·685 +	Diff.	tan = 4·685 +	Diff.
° ′					
2 35	9300	4278		8693	
			19		39
36	9360	4259		8732	
			20		38
37	9420	4239		8770	
			19		38
38	9480	4220		8808	
			20		39
39	9540	4200		8847	
			19		39
40	9600	4131		8886	
			20		40
41	9660	4161		8926	
			20		39
42	9720	4141		8965	
			20		39
43	9780	4121		9004	
			20		41
44	9840	4101		9045	
			20		40
45	9900	4081		9085	
			20		41
46	9960	4061		9126	
			20		41
47	10020	4041		9167	
			21		41
48	10080	4020		9208	
			21		41
49	10140	3999		9249	
			21		41
50	10200	3978		9290	
			21		42
51	10260	3957		9332	
			20		43
52	10320	3937		9375	
			22		41
53	10380	3915		9416	
			21		44
54	10440	3894		9460	
			21		42
55	10500	3873		9502	
			22		43
56	10560	3851		9546	
			21		43
57	10620	3830		9589	
			23		43
58	10680	3807		9632	
			21		44
2 59	10740	3786		9676	
			22		44
3 0	10800	3764		9720	

Watford, Herts, March 4, 1861.

From a Letter from Professor Hansen to the Astronomer Royal, dated Gotha, 1861, *Feb.* 2.

(*Translated from the German.*)

"You express in your honoured letter the wish that I would soon publish the calculation of my Lunar Perturbations, and I can assure you that I myself fully take part in that wish. I am even occupied, as far as my other labours permit, with the performance of this: a work of tolerable size is already finished, and I hope soon to be in a condition to draw up the manuscript for press for the first treatise. As far as I have yet advanced in the new calculations, I have found no differ-

ence from the coefficients used in the Lunar Tables, which amounts to $0''{\cdot}1$; the new coefficients differ, at the most, from those of the Lunar Tables by a few hundredth parts of a second. My plan in this new investigation of the Lunar Perturbations stands firm, and cannot be altered.

"You wish further to know what I understand by the expression in my letter of 1854, Nov. 3, 'In my Lunar Tables I have provisionally used coefficients, which are not free from some empiricism,' and I will willingly communicate this to you. In the first place, I mean thereby the part of the motion of the line of nodes and of the line of apsides which is proportional to the time itself; and in the next place, the coefficient of the argument $8\,V - 13\,E$; nothing further, unless also the determination of the coefficient of the parallactic equation by observations be called empiricism. In order to be able to calculate those coefficients by theory alone, with such accuracy that they could be employed in the tables without anything further, one would be obliged to calculate the coefficients of the periodical perturbations with far greater exactness than is otherwise demanded; and this I considered to be superfluous, as it would have engrossed very much time. For the rest, I have found the coefficient of $8\,V - 13\,E$, by my last theoretical determination of it, by no means insensible, like Delaunay. Without the introduction of this coefficient, the observations show deviations at different epochs; but with the introduction of this, these deviations disappeared even to the last trace. I considered, therefore, its introduction as established, and reserve to myself a new theoretical determination of it, but cannot take this in hand until I shall have proceeded further in the new calculation of the remaining coefficients. I have, besides, some other inequalities of long period, which are caused by the planets; but as the coefficients of these inequalities are small, I have neglected them in the tables, in order to avoid too great extension.

"It is probably the recent publication of Delaunay which has led you, most highly-honoured colleague, to the inquiry which I have plainly answered above; and I see myself compelled, in relation thereto, to add that, in the comparison with the observations, I have taken in no old eclipse or other ancient observation. I have never gone beyond Bradley's observations, and nevertheless my tables represent the ancient observations with satisfactory agreement.

"I have already shown that the ancient eclipses cannot be satisfied by the secular variation of Adams and Delaunay (*Comptes Rendus*, tome l. No. 10). I have now made trial of it, omitting the inequality dependent upon $8\,V - 13\,E$, but find the effect of this very trifling, and almost the same enormous differences. I would gladly have said nothing of this until my new calculation of the secular variation was finished; but with the inducement which you have given me, I cannot

refrain from bringing forward what I have found about a year ago in relation to this. The method which Messrs. Adams and Delaunay have pursued in the calculation of the secular variation of the moon's mean longitude requires, in the co-ordinates or the elliptic elements of the moon, the introduction of terms of the following form:—

$$at \begin{matrix}\sin\\ \cos\end{matrix} \left\{ ig + i'g' + \mathrm{K} \right\} + \frac{b}{n} \begin{matrix}\cos\\ \sin\end{matrix} \left\{ ig + i'g' + \mathrm{K} \right\} \ldots\ldots \text{(A)}$$

where a and b are numerical coefficients, i and i' whole numbers, g and g' the mean anomalies of the Moon and of the Sun, K a function of the perihelion and of the nodes, and n the secular mean motion of the Moon. Against this nothing can be said; and Plana and Pontécoulant, who have attacked this principle, are in this respect in error. Methods, indeed, can be given in which the second class of the above-mentioned terms do not come into consideration; but if this matter be treated as Adams and Delaunay have done, these terms must be introduced. But—whence do these terms arise? They arise out of the following terms of the Sun's co-ordinates:—

$$a't \begin{matrix}\sin\\ \cos\end{matrix} \Big\} i'g' + \frac{b'}{n} \begin{matrix}\cos\\ \sin\end{matrix} \Big\} i'g' \ldots\ldots\ldots\ldots \text{(B)}$$

and the method which requires the complete taking into account of the terms (A) requires, of course, also the complete taking into account of the terms (B), and these are not small. The greatest of the coefficients denoted by b' exceeds 90″. Further, the part of the perturbation-function of the Moon depending upon the planets contains terms which may also contribute to the secular variation of the Moon's mean longitude: these are, however, smaller than those above.

"All the memoirs of Messrs. Adams and Delaunay on this matter which have come into my hands I have carefully looked through, but I have not been able to remark that regard had been taken of the above coefficients denoted by b', or of those depending upon the planets. Until I am convinced of the contrary, therefore, I must assume that these terms have not been taken into account; and I have in this, again, a ground for the suspicion that Delaunay may also have overlooked terms in the latest calculation of the coefficient of 8 V − 13 E.

"I can, besides, affirm that even in Adams' first memoir (received and read June 16, 1853) combinations have been overlooked* which, indeed, for the coefficient there calculated, accidentally destroy each other, but whose continued omission must necessarily make the terms of the higher orders incorrect. We find, in the memoir named, in the longitude,

* In the original thus, "die zwar für den dort berechneten Coefficienten sich zufällig aufheben, aber deren fortgesetzte Uebergehung nothwendig die Glieder der höheren Ordnungen unrichtig machen muss."—Ed.

$$+\frac{295}{24}m^2\frac{e'\,d\,e'}{n\,d\,t}\cos(2v-2mv)-\frac{413}{48}m^2\frac{d\,e'}{n\,d\,t}\cos(2v-2mv-c'mv)*$$

$$+\frac{59}{48}m^2\frac{d\,e'}{n\,d\,t}\cos(2v-2mv+c'mv);*$$

while these coefficients are respectively =

$$+\frac{74}{3}m^2,\qquad -\frac{215}{48}m^2,\qquad +\frac{257}{48}m^2.$$

In the radius, we there find

$$+\frac{95}{12}m^2\frac{e'\,d\,e'}{n\,d\,t}\sin(2v-2mv)-\frac{133}{24}m^2\frac{d\,e'}{n\,d\,t}\sin(2v-2mv-c'mv)*$$

$$+\frac{19}{24}m^2\frac{d\,e'}{n\,d\,t}(\sin 2v-2mv+c'mv);*$$

while these coefficients are respectively

$$+\frac{203}{12}m^2,\qquad -\frac{61}{24}m^2,\qquad +\frac{91}{24}m^2.$$

"It appears that the combination of the term $3\frac{d\,e'}{n\,d\,t}\cos c'mv$ with the other entering terms has been overlooked.

"In conclusion, I must remark that I shall never be able to favour the development of the Lunar Perturbations in series according to the powers of m, unless it is proved,

"(1.) That these series converge;

"(2.) If this is the case, that the sum of the undeveloped terms of each one of these series can be assigned with sufficient approximation.

"That the first terms of a series decrease is no proof of the convergence of a series, for many diverging series can be brought forward in which this case occurs. It is also known that in slowly converging series the sum of the small terms not taken into account may often amount to something considerable."

Results of Observations of the Solar Eclipse of 1860, *July* 18, *made at the Royal Observatory, Greenwich, for determination of the Errors of the Tabular Elements of the Eclipse.* By G. B. Airy, Esq., Astronomer Royal.

Before leaving the Observatory for observation of the Totality of the Eclipse in Spain, I drew up a set of Instructions

* In Prof. Hansen's manuscript the coefficients of these terms are written $\frac{e'\,d\,e'}{n\,d\,t}$.—Ed.

for observation of the Eclipse at Greenwich, framed with the intention of giving means for ascertaining the errors of all the tabular elements of the Eclipse, namely, the difference of right ascension of centres of Sun and Moon, difference of north polar distance of centres of Sun and Moon, and semidiameters of Sun and Moon. The general scheme was as follows:—

1. From the beginning, at $1^h\ 38^m$, Greenwich mean solar time, to $1^h\ 55^m$, observations of the difference of N.P.D. of the cusps were to be made. These would show an effect of excess of Moon's R.A., increased by an excess of sum of semidiameters.

2. From $1^h\ 55^m$ to $2^h\ 15^m$, observations of the difference of R.A. of the cusps were to be made. These would show an effect principally of excess of Moon's N.P.D.

3. From $2^h\ 15^m$ to $2^h\ 45^m$, observations of the difference of R.A. of the Sun's 1 L. and Moon's 1 L. were to be made. These would show an effect of excess of Moon's R.A., diminished by an excess of Moon's semidiameter, but increased by an excess of Sun's semidiameter.

4. From $2^h\ 45^m$ to $3^h\ 20^m$, observations of the difference of N.P.D. of Sun's N. L. and Moon's N. L. were to be made. These would show an effect of excess of Moon's N.P.D., diminished by an excess of Moon's semidiameter, but increased by an excess of Sun's semidiameter.

5. From $3^h\ 20^m$ to $3^h\ 53^m$ (the end), observations of the difference of N.P.D. of the cusps were to be made. These would show an effect of excess of R.A. of Moon's centre, diminished by an excess of sum of semidiameters.

The observations No. 5 would form a valuable combination with No. 1, but they were not absolutely necessary. A very slight examination of the scheme will show that Nos. 1, 2, 3, 4, will give all the corrections of elements required.

The observations were made with the Great Equatoreal, under the general superintendence of Mr. Main, by Mr. Carpenter, assisted by Mr. Criswick and junior computers in the reading of microscopes, &c. The observations, Nos. 1, 2, 3, 4, were obtained in full number; the numbers of comparison-pairs being respectively 12, 27, 19, 18; but No. 5 was totally lost from clouds.

The observed measures were compared with the corresponding quantities computed by a laborious process from the places in the *Nautical Almanac*. To every numerical element of the *Nautical Almanac* was attached a symbolical correction, and the multiples of these symbolical corrections, affecting each of the quantities measured (whether depending on cusps or on limbs, and whether in R.A. or in N.P.D.), were carefully computed. Thus the comparison of each measured quantity with the corresponding computed quantity gave an equation containing multiples of all the corrections to elements and one numerical term.

Without entering further into the details (which will more

properly appear in the *Greenwich Observations*) the corrections were found as follows:—

Correction to excess of Moon's R.A. over Sun's R.A.	$-38^{s}\cdot63$
Correction to excess of Moon's N.P.D. over Sun's N.P.D.	$-8''\cdot75$
Correction to Sun's Semidiameter	$-1''\cdot45$
Correction to Moon's Semidiameter	$-2''\cdot97$

To these I may add the following:—

Mr. Ellis found, by an imperfect meridian observation of the Sun,—

Correction to Sun's R.A. $+0^{s}\cdot13$; to Sun's N.P.D. $-2''\cdot49$

And, by good altazimuth observations of the Moon,—

Correction to Moon's R.A. $-2^{s}\cdot40$; to Moon's N.P.D. $-4''\cdot57$

Hence,

Correction to excess of Moon's R.A. over Sun's R.A.	$-37''\cdot95$
Correction to excess of Moon's N.P.D. over Sun's N.P.D.	$-2''\cdot08$

Of the two sets of results, those from the Equatoreal observations are undoubtedly by much the more accurate.

These corrections, it will be remembered, apply to the places in the *Nautical Almanac;* that is, to places computed by Burckhardt's Tables.

From the numbers given by Mr. Hind, in his circulated calculations of the eclipse, it appears that the places of the Moon given by Hansen's Tables, on July 18, 1^{h}, differ from those given by Burckhardt's Tables, by $-2^{s}\cdot33$ in R.A. and $-4''\cdot0$ in N.P.D.; and the Moon's semidiameter from Hansen's Tables is less than that from Burckhardt's by $0''\cdot6$. Also the places of the Sun given by Le Verrier's Tables differ from those given by Burckhardt's Tables, by $+0^{s}\cdot17$ in R.A. and $+0''\cdot8$ in N.P.D.; and the Sun's semidiameter from Le Verrier's Tables is less than that from Carlini's Tables by $1''\cdot7$. Using these in combination with the numbers above, it appears that the corrections to the results from Hansen's and Le Verrier's Tables were

Correction to excess of Moon's R.A. over Sun's R.A.	$-1''\cdot1$
Correction to excess of Moon's N.P.D. over Sun's N.P.D.	$-4''\cdot0$
Correction to Sun's Semidiameter	$+0''\cdot3$
Correction to Moon's Semidiameter	$-2''\cdot4$

Royal Observatory, Greenwich,
1861, *March* 6.

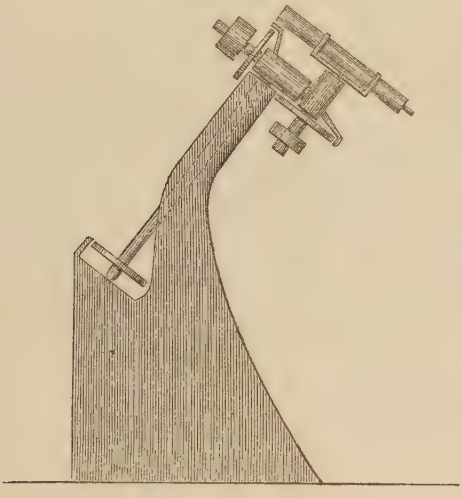
Suggestion of a new Astronomical Instrument, for which the name "Orbit-Sweeper" is proposed. By G. B. Airy, Esq., Astronomer Royal.

In reflecting on the possibility of picking up De Vico's comet, by aid of the sweeping ephemeris prepared by Mr. Hind, I could not but observe how ill adapted for this purpose are the instruments in ordinary use. It will be remarked that, in this and similar cases, it is not a general search in all directions about a given point that is required. For every day, places are computed which lie in a definite line drawn upon the celestial sphere; and, while it may be requisite to sweep many degrees along that line, it will be useless to direct the telescope many minutes above it or below it. The geometrical conception of the matter will at once explain this. The elements of the comet's orbit, considered as a curved line through space of three dimensions, are known with considerable accuracy; but the time of the comet's return to perihelion is not known with accuracy, and therefore the actual place of the comet upon that curved line is not known with accuracy; all that is accurately known being, that the comet will be somewhere on that line. And in fact, the definite line drawn upon the celestial sphere (of which I have spoken) is the perspective representation of a portion of the comet's orbit as viewed at a certain instant of time from the earth; and therefore the optical place of the comet must be somewhere upon that line traced on the celestial sphere, but we cannot say exactly where.

An unmounted telescope can scarcely be used to sweep along a definite track through the sky, which is defined by numerical elements of right ascension and north polar distance, but cannot easily be referred to distinguishable stars occurring in the breadth of every field of view. And the mounting which for all ordinary purposes is the most convenient, namely, that of the equatoreal, cannot be easily applied here. For sweeping in right ascension only, or (with the aid of clockwork movement, which every equatoreal ought to have) for sweeping in polar distance only, it is excellent; but for sweeping in an inclined direction, it is no better than an unmounted telescope.

I have arranged a form of mounting adapted to sweeping in all directions, a model of which (of about half-size dimensions) I ask leave to exhibit to the Society. The general form of the instrument is that of a German Equatoreal. The polar axis is similar to that of a German Equatoreal; but, in order to allow freedom of rotation to all parts, the fixed mass in which the polar axis turns must not be a pier widening downwards from the upper bearing of the polar axis, but must for some distance be a hollow tube or trunk. The cross-axis will be similar to that of a German Equatoreal; but instead of carrying the Telescope, it will carry a small trunk in which a second cross-axis turns.

This second cross-axis carries the Telescope. The polar axis should have a divided hour-circle, and clock-work movement (omitted in the model), the first cross-axis must have a graduated circle, and a clamp or steps by which it may be firmly fixed in a given position; the second cross-axis carrying the telescope must have a graduated circle, and must have two stops limiting its sweeping motion to any arbitrary extent. The second cross-axis must have a counterpoise for the telescope; the first cross-axis must have a counterpoise sufficient to balance both the telescope and the telescope's counterpoise. The annexed figure was drawn from the model.



It will be easily seen that, by giving a proper position in rotation to the first cross-axis, the inclination of the second cross-axis to an astronomical meridian may be made any whatever, and therefore the inclination of the circle in which the telescope will sweep may be made any whatever; and it may be made to coincide with the definite line drawn on the celestial sphere in which the comet is to be sought. And, by means of its stops, the extent of that line through which its sweep is to be made may be limited as we may think fit.

To such an instrument I would propose to attach the name "Orbit-Sweeper."

If I were to construct such an instrument expressly for the purpose of sweeping orbits, I would make it of wood. Such a construction would be more than sufficiently accurate for the purpose in question; its expense would be very small, it would be lighter than metal, for the same degree of stiffness; and its counterpoises, &c. would be light.

But it would be easy to adapt a common German Equatoreal to the same purpose, if the support of the polar axis widened out so little as to allow the telescope-counterpoise on the second cross-axis to rotate round it (for which purpose it might be worth while to substitute a trunk-support, as is described above). The possible inconveniences would be, that the counterpoises would be rather heavy, and that there might be a little instability from the use of three axial movements instead of two. The ordinary use of the Equatoreal would in no way be impeded.

There is one special application of such an instrument which deserves notice. It is known to lunar-observers and to lunar-photographers, and to none better than to some of the active members of this Society, how difficult it is to follow the Moon with an equatoreal. Now it is easy to compute the Moon's apparent motion in right ascension and north polar distance (both corrected for the continued change of parallax), and therefore to compute the inclination of the Moon's apparent orbit through the sky; and to this the Orbit-Sweeper might be at once adjusted. It would be equally easy to compute the Moon's apparent velocity in that orbit; and there must be a special clock movement, acting on the clamp of the circle of second cross-axis, with the proper speed; there would be little difficulty in arranging this. Thus I anticipate that a given spot on the Moon might be automatically kept for a long time under the cross wires of a telescope without discoverable motion.

Royal Observatory, Greenwich,
March 6th, 1861.

Mr. C. V. Walker received from the Astronomer Royal, and with his permission communicated to the Society, some letters and a paper on Controlling Clocks by Electricity.

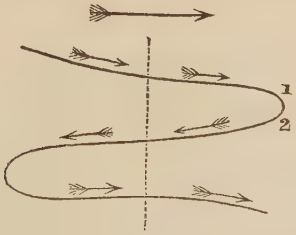
In a letter, dated 18th Feb. 1861, Mr. Airy writes: —

"I have been reading your interesting account of the time-signal operations, which will convey a great deal of information to the public.

"In regard to the interruption of the duration of action of the foreign current upon the pendulum, I think it will not succeed, for the following reason:—Let the curve which follows be understood to represent the pendulum-oscillations, the uniform course of time being downwards, and the direction of motion of the pendulum being shown by the arrows. Also, let the external arrow show the direction of the foreign force. The figures 1 and 2 merely show which part of the swing is, 1 towards the right and 2 towards the left.

"Now the rule for efficiency of external force in maintaining

pendulum-motion is this:—If the direction of force agrees with the direction of motion, it maintains the vibration; if it is opposed, it diminishes the vibration. Thus, if the external



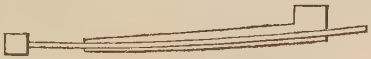
force act during any part of 1, it maintains the vibration; if during any part of 2, it diminishes it; if equally on both, it produces no effect.

"Now any ordinary spring-contact that your pendulum can make will equally affect 1 and 2, and therefore will not serve. It will expose you as much to the chance of force opposing the vibration as of force assisting the vibration.

"Possibly you may do it in some such way as this:—

S, Spring.
P, Passing spring.
s, Pendulum stud.
b, Banking pin.
p, Piece carried by a spring for contact,

the arrangement of spring and passing-spring exactly as in my 10-inch clock; the form of the passing-spring, as you look from above, being



Then the pendulum-stud, in swinging to the right, will lift the passing-spring and the spring to contact, but will let it snap down before the end of vibration. In swinging to the left, it will press the passing-spring only down, and at last let it snap up.

"The spring-work must be very light."

And with a subsequent letter, dated the 20th Feb., was sent a paper containing the theory of the subject, as follows:—

Theory of the Regulation of a Clock by Galvanic Currents acting on the Pendulum. By G. B. Airy, Esq., Astronomer Royal.

I. Effect of force upon a pendulum.

The long curve is supposed to represent the swing of the pendulum; and the long arrows represent the direction of its swing. The short arrows represent the direction of a galvanic force, and the place of the pendulum when the galvanic force is acting.

At No. 1	the force	quickens the rate most,	does not alter the arc,
2	—	quickens the rate,	increases the arc,
3	—	does not alter the rate,	increases the arc most,
4	—	retards the rate,	increases the arc,
5	—	retards the rate most,	does not alter the arc,
6	—	retards the rate,	diminishes the arc,
7	—	does not alter the rate,	diminishes the arc most,
8	—	quickens the rate,	diminishes the arc,
1	—	quickens the rate most,	does not alter the arc.

If the galvanic force act the opposite way, the figure may be turned round the vertical line in its own plane, so as to reverse the figure in regard to right and left, and every remark is still correct.

II. In applying this to the regulation of a clock, it must be borne in mind,—

1st. As it is essential that the clock should continue to go (though erroneously) when the galvanism is accidentally interrupted, the galvanic force is always to be supposed subordinate to the maintaining power in the clock.

2d. The galvanic force must be large enough to do its duty of regulation, and, therefore, when applied at the most favourable place (No. 1 or 5, as the case may be), the galvanic force must be too large and must overdo the regulation.

III. Hence, considering the different cases,—

(A.) Suppose the pendulum (which is to be regulated) to go, by its own motion in connexion with its own clock, slower than the regulating clock.

We now want to quicken the rate. Start the clock, therefore, so that the galvanic force acts at No. 1.

By the remark II. 2d, this force will over-accelerate the

rate. In a short time, therefore, we shall have the action at No. 2. Here the rate is quickened in a minor degree, and the place of No. 2 will change till it is quickened exactly in the proper degree. At the same time the arc is increased, *i. e.* the maintaining power is increased, and there is no fear of the clock stopping. This will do.

If we had started the clock for force at No. 5, it would have gone through the stages 4, 3, to 2. This will do, but the process will, perhaps, be a little longer. There is no fear of the clock stopping.

(B.) Suppose the pendulum which is to be regulated to go quicker than the regulating clock.

We now want to retard the rate. Let the force act at No. 5. This will over-retard the rate, and will bring it gradually to the state 4, where the retardation is exactly correct. The maintaining power is increased. This will do.

If the force had acted at No. 1, the rate would have been much accelerated, and we should quickly have had the states 2, 3, 4. There is no fear of the clock stopping.

If we started the clock in the state 7, we might run the risk of stopping it.

IV. Hence the following rule appears to be sufficient, in addition to II. (1st) and (2d):—

Start the clock so that the force acts at either extremity of the swing. In case (A) it will soon come to state 2, and will stop there; in case (B) it will soon come to state 4, and will stop there.

Results of the Observations of Small Planets made with the Transit-Circle; and Eclipses, Occultations, and Transits of Jupiter's Satellites; observed at the Royal Observatory, Greenwich, during the months of January and February, 1861.

(*Communicated by the Astronomer Royal.*)

(All observations of N.P.D. are corrected for Refraction and Parallax.)

Hebe (6).

Mean Solar Time of Observation.		R.A. from Observation.	N.P.D. from Observation.
	h m s	h m s	° ′ ″
1861, Feb. 25	12 57 35·9	11 21 2·54	75 34 52·78
28	12 43 16·3	11 18 30·30	75 4 25·76

Parthenope (11).

Mean Solar Time of Observation.		R.A. from Observation.	N.P.D. from Observation.
	h m s	h m s	° ′ ″
1861, Feb. 28	13 7 0·5	11 42 18·41	82 37 18·52

Flora (8).

Mean Solar Time of Observation.	R.A. from Observation.	N.P.D. from Observation.
h m s	h m s	° ′ ″
1861, Jan. 2 8 20 15·3	3 10 2·38	78 21 48·23
3 8 16 39·0	3 10 22·00	78 14 25·92
5 8 9 33·0	3 11 7·93	77 59 19·92
8 7 59 8·8	3 12 31·72	77 36 5·73
9 7 55 44·8	3 13 3·70	77 28 16·07
11 7 49 2·9	3 14 13·86	77 12 15·58
21 7 17 22·8	3 21 54·10	75 49 33·06
29 6 54 7·5	3 30 7·47	74 41 40·86
31 6 48 25·8	3 32 17·98	74 24 39·52

Melpomene (18).

Mean Solar Time of Observation.	R.A. from Observation.	N.P.D. from Observation.
h m s	h m s	° ′ ″
1861, Jan. 2 14 30 42·9	9 21 30·86	81 34 32·86
3 14 26 11·5	9 20 55·21	81 29 35·69
5 14 17 3·5	9 19 38·87	81 18 53·23
7 14 7 50·2	9 18 17·17	81 7 28·94
8 14 3 10·8	9 17 33·59	81 1 26·13
9 13 58 30·1	9 16 48·64	80 55 12·67
21 13 0 46·0	9 6 13·77	79 27 30·10
29 12 21 16·1	8 58 9·85	78 19 38·07
Feb. 2 12 1 27·8	8 54 4·51	77 44 25·14
11 11 17 16·1	8 45 14·56	76 25 24·15
15 10 57 59·1	8 41 40·61	75 51 37·84
25 10 11 17·8	8 34 17·13	74 34 2·61
28 9 57 47·5	8 32 34·32	74 13 12·50

Fides (37).

Mean Solar Time of Observation.	R.A. from Observation.	N.P.D. from Observation.
h m s	h m s	° ′ ″
1861, Jan. 2 13 49 50·6	8 40 31·77	66 29 23·42
3 13 45 6·9	8 39 43·89	66 25 59·54
7 13 25 59·9	8 36 19·97	66 12 39·09
8 13 21 9·3	8 35 25·23	66 9 16·08
9 13 16 18·3	8 34 29·92	66 5 54·26
21 12 17 6·8	8 22 27·36	65 29 42·79
28 11 42 26·5	8 15 17·30	65 14 1·19
29 11 37 31·2	8 14 17·72	65 12 17·67
Feb. 2 11 17 58·9	8 10 28·42	65 6 1·48
6 10 58 41·9	8 6 54·52	65 2 9·01
11 10 35 7·5	8 2 59·02	64 59 47·75

Fortuna (19).

Mean Solar Time of Observation.	R.A. from Observation.	N.P.D. from Observation.
	h m s	h m s	° ′ ″
1861, Jan. 9	7 25 10·9	2 42 24·80	75 33 44·65

Massilia (20).

Mean Solar Time of Observation.	R.A. from Observation.	N.P.D. from Observation.
	h m s	h m s	° ′ ″
1861, Jan. 2	10 57 34·7	5 47 47·65	67 45 48·55
3	10 52 43·4	5 46 52·03	67 46 4·10
8	10 28 48·2	5 42 35·69	67 47 16·72
9	10 24 6·1	5 41 49·45	67 47 27·05
11	10 14 47·5	5 40 22·37	67 47 49·78
28	9 1 22·5	5 33 46·86	67 47 9·94
29	8 57 23·8	5 33 44·01	67 46 53·58
31	8 49 33·4	5 33 45·47	67 46 9·69
Feb. 2	8 41 52·1	5 33 56·04	67 45 26·40
6	8 26 56·4	5 34 44·11	67 43 26·54
11	8 9 7·0	5 36 34·55	67 40 26·93
15	7 55 28·8	5 38 40·25	67 37 51·14
18	7 45 36·8	5 40 36·38	67 35 45·50
27	7 17 39·4	5 48 3·31	67 29 33·29
28	7 14 41·6	5 49 1·62	67 28 54·77

Lutetia (21).

Mean Solar Time of Observation.	R.A. from Observation.	N.P.D. from Observation.
	h m s	h m s	° ′ ″
1861, Jan. 8	10 46 9·5	5 59 59·86	65 11 17·11
21	9 44 33·9	5 49 29·46	65 3 45·52

Proserpine (26).

Mean Solar Time of Observation.	R.A. from Observation.	N.P.D. from Observation.
	h m s	h m s	° ′ ″
1861, Jan. 29	12 38 45·0	9 15 41·60	68 9 14·21
Feb. 2	12 19 11·2	9 11 50·77	67 51 19·63
15	11 15 39·6	8 59 24·03	67 3 4·55

Amphitrite (29).

Mean Solar Time of Observation.	R.A. from Observation.	N.P.D. from Observation.
	h m s	h m s	° ′ ″
1861, Jan. 3	7 45 54·3	2 39 32·25	66 4 28·67
8	7 28 1·9	2 41 19·76	66 7 50·55
21	6 44 54·4	2 49 20·38	66 3 11·88

No Occultations of Stars by the Moon were observed.

Eclipses, Occultations, and Transits of Jupiter's Satellites.

Day of Observation.	Satellite.	Phenomenon.	Mean Solar Time. h m s	Observer.
1861. Jan. 2	III	Ingress, bisection (*a*)	9 15 22·7	C.
2	I	Occ. reapp. last cont.	12 54 3·7	C.
2	III	Egress, last cont.	12 56 33·3	C.
3	I	Egress, first cont.	9 58 30·7	J. C.
3	I	,, bisection	10 2 30·1	J. C.
3	I	,, last cont.	10 6 29·4	J. C.
9	III	Shad. Ingr. bisection	9 50 7·9	J. C.
9	I	Ecl. disapp.	11 37 46·3	J. C.
9	II	Ingress, bisection	12 23 12·9	J. C.
9	III	Ingress, bisection	12 42 24·8	J. C.
9	III	Shad. Egr. bisection	13 28 2·3	J. C.
11	II	Occ. reapp. first app.	9 55 3·8	C.
11	II	,, last cont.	9 57 3·5	C.
23	II	Ingress, first cont. (*b*)	16 50 19·2	A. D.
23	II	,, bisection (*b*)	16 52 23·9	A. D.
23	II	,, last cont. (*b*)	16 54 23·6	A. D.
Feb. 2	I	Ingress, last cont. (*c*)	9 13 7·4	M. D.
2	I	Egress, first cont.	11 27 45·3	M. D.
2	I	,, last cont.	11 31 44·7	M. D.
6	IV	Ecl. disapp.	8 7 17·9	E.
6	IV	Occ. reapp. bisection	13 46 37·2	E.
6	IV	,, last cont.	13 51 6·5	E.
11	I	Egress, bisection	7 37 26·5	C.
11	I	,, last cont.	7 39 11·2	C.
18	I	Ingress, first cont.	7 3 45·1	A. D.
18	I	,, bisection	7 5 44·7	A. D.
18	I	,, last cont.	7 7 14·5	A. D.
18	I	Egress, bisection	9 24 7·1	A. D.
18	I	,, last cont.	9 26 6·7	A. D.
21	III	Ingress, first cont.	12 7 49·3	K.
21	III	,, bisection	12 10 20·9	K.
21	III	,, last cont.	12 15 20·1	K.
28	III	Ingress, first cont.	11 48 35·4	N.
28	III	,, bisection	11 52 4·8	N.
28	III	,, last cont.	11 54 39·4	N.
28	III	Shad. Ingr. last cont.	13 38 32·4	N.

(*a*), The images very tremulous. (*b*), The limbs of the planet badly defined, especially at the last contact. (*c*), Unsatisfactory.

The initials E., C., J. C., M. D., K., A. D., and N., are those of Messrs. Ellis, Criswick, Carpenter, Dolman, Kerschner, Davis, and Newcomb.

Discovery of Minor Planet (64).

A telegraphic despatch from Marseilles appeared in Le Verrier's *Bulletin* for the 6th of March, announcing this discovery, which, by a subsequent account, proves to be due to M. Tempel. The places given are

	h m	h m s	° ′
March 4	14 40	R.A. 12 3 56	Decl. −2 5
3	14 11	12 3 11	−2 1

The discovery of the Minor Planet (63) and of the last-mentioned Planet (64) was announced from the Chair by the President.

A third discovery has since followed closely on those just referred to, the account of which is given from Le Verrier's *Bulletin* of March the 10th:—

Discovery of Minor Planet (65).

This planet was also discovered by M. Tempel at Marseilles, in the immediate neighbourhood of (64). The first place given in the despatch is:—

	h m	h m s	° ′ ″
March 9	11 24	R.A. 12 6 19·5	Decl. +1 1 46

The following positions observed by M. Tempel of the Planets (62) and (64) may be added:—

Minor Planet (62).

	Marseilles M.T. h m s	R.A. h m s	Decl. ° ′ ″
March 2	10 45 31	10 53 8·4	+6 20 9
3	8 55 3	10 52 10	+6 24 12
4	10 31 38	10 51 4	+6 28 43
6	9 47 33	10 49 3	+6 34 41
8	9 53 44	10 47 0	+6 41 19

Minor Planet (64).

	Marseilles M.T. h m s	R.A. h m s	Decl. ° ′ ″
March 4	14 40	12 3 56	−2 5 27
5	14 11 36	12 3 10·8	−2 1 23
6	10 32 8	12 2 31·7	−1 56 53
6	13 46 24	12 2 24·5	−1 56 15
7	11 42 40	12 1 41	−1 51 53
8	10 34 53	12 0 54	−1 48 26

It is not stated, but is probable, that the above places are corrected for refraction, but not for parallax.

On a Method for determining Longitude without Clock.

By M. Radau.

In the *Géodésie d'Ethiopie*, par M. D'Abbadie, I have suggested a method for finding the latitude without needing a clock, by means of an altazimuth, and have explained the method of corresponding azimuths, which has been proposed by M. D'Abbadie, and may be used for ascertaining the meridian also without chronometer (see *Astr. Nach.*, No. 1298). But it would seem to be much less easy to find out the longitude in the case where a traveller is deprived of this latter instrument, since the clock is generally considered as being indispensable for such an observation. I, therefore, think it right to communicate a method I have conceived some time ago, which seems to me, when well employed, to answer that purpose in a satisfactory manner. I suppose, at first, the latitude of the place to be already known. It is then possible to obtain the longitude by means of alternate observations of the Moon and a Star, as well in altitude as in azimuth. The Star's altitudes may be used for calculating its azimuths and hour-angles: the former supply the orientation of the Moon's azimuths; the latter afford, with a sufficient degree of accuracy, the time of the mean of the lunar observations, which is wanted for computing a double ephemeris of the Moon's azimuths and altitudes, with two assumed longitudes, l and $l + 100^s$. Hence we may deduce, by interpolation, two systems of altitudes corresponding, in each case, to the observed azimuths of the Moon, and the comparison of these two systems leads to the determination of the true longitude. The correction Δl, which the assumed longitude l has to undergo when the zenith distance z, computed for a given azimuth, differs from observation by Δz seconds in arc, depends upon this formula:—

$$\frac{\Delta l}{\Delta z} = \frac{1 - \alpha}{\nu} \cos q + \frac{\sec \delta}{15} \sin q,$$

where q is the parallactic angle, δ the moon's declination, ν her motion in declination per second, and α that in right ascension (given in time is also the longitude). We shall have, of course, $\frac{1}{\nu} > 4$, $1 - \alpha > 0{\cdot}95$, and $\frac{\sec \delta}{15}$ between 0·07 and 0·08.

It is evident that for those observations the Moon must be near the equator, because, in that case, the quantity ν is considerable enough, and likewise, that it is necessary to observe near the prime vertical, where the angle q is at a maximum. For this latter reason the method is also better suited to tropical countries than to higher latitudes. Besides, it would be well to take the Moon in the east when her declination is increasing (ν pos., sin q neg.) and in the west when it is diminishing (ν neg., sin q pos.). I have had no opportunity

for making a trial of this method, and it would be very satisfactory for me to learn whether observers find it to be advantageous in practice.

Paris, January 1861.

Mr. Nasmyth, in a private letter to Mr. De La Rue, dated 5th Feb. 1861, states that he finds that the entire luminous surface of the sun is resoluble into the most complex superposition of elementary lense-shaped figures, arranged without any approach to symmetrical order in the details, but rather (if the term may be used) in a sort of regular random scattering; the letter was accompanied by a photograph from the original drawing, and an illustrative paper model.

In a letter, dated the 5th March, 1861, Mr. S. Gorton calls attention to the extremely dark appearance of the 3d and 4th Satellites of *Jupiter* in transit over the disk of the Planet, as seen by him and one or two other observers, the transit of the 3d Satellite on the 28th February, and that of the 4th Satellite on the 3d March; and he incloses a copy of his notes of the observations, as also of those of the transit on the 4th March of the 1st Satellite, which was almost invisible on account of its brightness. The dark appearance of the 4th Satellite on the transit of the 3d March is also noticed in a communication from Mr. T. W. Burr, whose account of the observation has, however, appeared in print elsewhere. The phenomenon, as regards both the 3d and 4th Satellites, has been frequently observed, see *Monthly Notices*, vol. xx. pp. 57 and 245, 246.

M. Goldschmidt, in a letter dated the 2d March, 1861, addressed to the Foreign Secretary, expresses his gratitude to the Royal Astronomical Society for the recompense and encouragement given to him by the award of the Medal.

There are contained in the *Comptes Rendus* (t. xlix., p. 673, t. l., p. 474, and t. li., p. 964) notices of a memoir "Sur les Cartes Géographiques," by M. A. Tissot. In the first part the author gives the law of deformation about each point, whatever the system of representation may be; in the second, he compares together those which have been employed or only proposed, for the construction of maps of the world; in the third part he resolves the question,—to find the best mode of

projection for any particular country. There exists an infinity of systems of representation, which do not modify the angles; but in the case of a country such as Russia, of an exceptional extent in all directions, even in selecting the system which reduces to a minimum the greatest variation of distance, the scale would undergo large variations in the extreme portions of the map, unless indeed the country represented be divided into regions having each of them its own map. The following are consequently the most important cases. 1°, a portion of the terrestrial surface of small extent in latitude, but of any extent whatever in longitude; 2°, one of small extent in longitude, but of any extent whatever in latitude; 3°, a country of moderate extent in latitude and longitude, as France, Spain, &c.

Let L be the latitude of any point, L_0 that of a central point, m the longitude of the first point from the second, r the radius of the parallel the latitude whereof is L, r_0 that of the parallel the latitude whereof is L_0, s the arc of meridian comprised between these two parallels, x and y the rectangular coordinates on the map, of the point the latitude whereof is L and longitude m.

In the first case the best system of projection is given by the formulæ

$$(1) \qquad x = S + \frac{1}{2} r m^2 \sin L, \quad y = r m \left(1 + \frac{1}{6} m^2 \cos 2 L\right).$$

In the second case, putting

$$R_0 = r_0 \operatorname{cosec} L_0, \quad R = R_0 - S - \frac{1}{6} S^3, \quad \varphi = m \sin L_0,$$

then the formulæ are

$$(2) \qquad x = R_0 - R \cos \varphi, \quad y = r \sin \varphi.$$

In the third case if N_0 is the great normal of the meridian at the latitude L_0 (? the portion of the normal, intersected between the point on the surface and the polar axis), and if μ denote the variable quantity $m \cos L_0$, then the formulæ are

$$(3) \qquad x = s + \frac{1}{2} N_0 \tan L_0 \mu^2 + \frac{1}{3} A s^3 - B s^2 \mu + C s \mu^2 + \frac{1}{3} B \mu^3,$$

$$y = r m + A s^2 \mu - B s \mu^2 + \frac{1}{3} C \mu^3,$$

where $L - L_0$ may be substituted in the place of s, except in the first term of the expression for x; A, B, C, are constant coefficients, the third of which is connected with the first by the equation

$$2 (A + C) \cos^2 L_0 = \cos 2 L_0,$$

and A and B depend on the form of the contour of the country, and are obtained as follows; first tracing the contour by referring each of its points to two rectangular axes by means of the co-ordinates $L - L_0$, μ, it is easy by a few graphical trials to determine in magnitude and position the enveloping ellipse such that the diameter inclined 45° to the two axes is the least possible. Let $2d$ be the length of this minimum diameter, $2a$ that of the corresponding major axis, α the inclination of such major axis to the axis of the co-ordinates μ; then

$$(4) \qquad A = \frac{1}{2}\left(\cos^2\alpha - \frac{d^2}{2a^2}\cos 2\alpha\right), \quad B = \frac{1}{4}\left(1 - \frac{d^2}{a^2}\right)\sin 2\alpha,$$

the centre of the ellipse will give the central point of the map, and consequently the latitude L_0, an approximate value whereof will have been sufficient for the purpose of this preliminary construction.

For certain exceptional contours the mode of projection must be somewhat modified. Lastly, there may be introduced on the right-hand sides of the equations (1), (2), and (3), a constant factor which it is easy to determine for each country in particular, and of which the effect is to diminish by one-half the greatest alteration in length, rendering this positive in certain regions and negative in others.

Applied to France, the foregoing researches give

$$(5) \qquad A = 0{\cdot}306, \quad B = 0, \quad C = -0{\cdot}368, \quad L_0 = 41^\circ\,40'$$

and the central meridian is that of Paris. Applied to Spain, the central meridian is that of Madrid, and the central parallel that of 40°; the formulæ are

$$x = s + 0{\cdot}42013\,\mu^2 + 0{\cdot}111\,s^3 - 0{\cdot}185\,s^2\mu,$$

$$y = r\,m + 0{\cdot}333\,s^2\mu - 0{\cdot}062\,\mu^3.$$

A table is given showing, for six different countries, the greatest alteration of angle and the greatest alteration of distance produced by the mode of projection adopted in the construction of the map of France by the Dépôt de la Guerre, and by one of those proposed in the Memoir.

For sale, an Equatoreal Telescope, 5 feet focus, 4·15 inches aperture; object-glass by Messrs. Cooke and Sons, of York; nine astronomical and three terrestrial eye-pieces; diagonal solar eye-piece and dark glasses; position and distance micrometer; iron mortar stand; declination circle, 14 inches diameter; right ascension circle, 6 inches diameter; clamps, hooks, joints, and handles. Apply to the Assistant Secretary.

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